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To augment low flow, reclaimed water from the Belmont Advanced Wastewater Treatment (AWT) Plant will be conveyed through the Belmont Force Main (discussed in Section 12 – Force Main Alternatives) and discharged through outfall structures into Fall Creek, Pogues Run, and Pleasant Run during dry weather periods. Per the directive of the City of Indianapolis Department of Public Works (DPW), the outfall structure evaluation focuses on civil engineering aspects of the project.

13.1 ALTERNATIVES

Outfall alternatives, such as cascade aerators and constructed wetlands, were evaluated based on the flow augmentation goals for all three creeks The intent of the outfall structures is to increase dissolved oxygen (DO) levels in the Belmont AWT Plant effluent prior to discharge into the creeks. The outfall structures will be located at selected discharge points along Fall Creek, Pogues Run, and Pleasant Run. The outfall alternatives were evaluated based on their ability to increase DO, civil engineering, and aesthetic aspects of the project.

13.1.1 Cascade Structures

Cascade structures are commonly used as outfall structures due to their visually pleasing appearance and can be designed to blend in with the surroundings. Cascade aerators are structures that involve a series of steps over which the reclaimed water can flow and aerate before entering the creeks.

Cascade aerators can increase the DO in the Belmont AWT Plant effluent to its saturation concentration and are recommended for the outfall structure. The preliminary cascade aerator designs presented herein were based on the U.S. Army Corps of Engineers (USACE) Design Manual, TM 5-814-3/AFM 88-11, Volume III, Paragraph 15-4, Post Aeration, which states the following: *The drop required for*

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cascade aeration in a stepped-weir structure or in a rapidly sloping channel filled with large rocks or concrete blocks will depend on the desired oxygen uptake: 2 feet of drop will be provided for each milligram per liter of dissolved oxygen increase required.

The DO saturation concentration is a function of water temperature. The assumed design scenario was based on the need for supplemental DO during warmer weather. In this scenario, the plant effluent DO saturation concentrations are at their lowest and the rate of DO depletion by biological processes in the receiving stream is at its highest. During the summer months when the Belmont AWT Plant effluent water temperature is approximately 77° Fahrenheit (F), the DO saturation concentration is approximately 8.4 milligrams per liter (mg/L). Data provided by DPW indicated the Belmont AWT Plant effluent DO concentration, sampled at the plant outfall to White River, is greater than 6.0 mg/L. Although the Belmont AWT Plant effluent data shows DO concentrations of 6.0 mg/L or greater, it is prudent to design the outfall structure(s) to account for potential DO loss as the effluent is pumped through the Belmont Force Main. Therefore, it was assumed that the DO concentration would be 4.0 mg/L at the Belmont Force Main terminus, prior to entering the cascade aerator structure. To increase the effluent DO concentration from 4.0 mg/L to the saturation concentration of approximately 8.4 mg/L, it was determined that approximately 10 feet of drop would be required over the cascade aerator structure.

The following outfall(s) alternatives were considered for the Belmont Force Main terminus at Fall Creek, Pogues Run, and/or Pleasant Run. The configurations are as follows:

- Stair-step cascade aerator structure
- Side-stream cascade aerator structure
- Side-stream cascade aerator structure alternative

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13.1.1.1 Stair-Step Cascade Aerator Structure

A preliminary design of the cascade aerator structure was developed. The proposed structure is a "wedding cake" configuration and consists of 10 stair-steps of concentric circles. Effluent from the Belmont Force Main would emerge vertically from the pipeline to the center of the top step. The reclaimed water cascades from the center of the structure from step to step, and is distributed equally around 360 degrees. Each circular step drops one foot and each step is four feet larger in diameter than the previous step. Plan and profile views of the structure are provided in Figure 13.1. The structure is recommended to be constructed of reinforced, cast-in-place concrete.

13.1.1.2 Side-Stream Cascade Aerator Structure

A side-stream aerator also was considered as an alternative to the "wedding cake" configuration. The side-stream aerator may be less likely to be damaged by large debris in the creek during periods of high flow. The side-stream alternative is a rectangular-shaped stair-step aeration structure. The effluent from the Belmont Force Main would cascade down from the top of the aerator structure, which is composed of 10 steps that are two feet in length. Each step has a 1-foot elevation drop and the width of the structure is dependent upon flow. The effluent is aerated as it flows from top to bottom in a series of steps. Figure 13.2 shows the plan and profile views of the side-stream aerator. The structure is recommended to be constructed of reinforced, cast-in-place concrete.

13. OUTFALL STRUCTURES

INSERT FIGURE 13.1

13. OUTFALL STRUCTURES

INSERT FIGURE 13.2

13. OUTFALL STRUCTURES

13.1.1.3 Side-Stream Cascade Aerator Alternative

A “natural” looking side-stream cascade aerator alternative (i.e., large rocks) was also considered. Similar to the side-stream aeration structures described above, it is expected that at least 10 feet of drop would be required. The rocks would be arranged in a manner similar to the shape and configuration of the side-stream cascade aerator previously shown on Figure 13.2, except the concrete steps would be replaced by large rocks similar to riprap. A concrete slab will be installed under the rocks and the rocks will be grouted in place to provide stability and eliminate the rocks from moving under the force of the water. Figure 13.3 shows the plan and profile views of the side-stream aerator alternative.

13.1.2 Constructed Wetlands

Constructed wetlands are engineered systems that use the natural ecosystem of wetlands for effluent polishing. Constructed wetlands are large in area; shallow in water depth (up to 2 feet); and have vegetation such as cattails, reeds, and rushes. As pretreated wastewater is applied to the system, the vegetation and microorganisms in the wetlands utilize the nutrients, such as nitrogen and phosphorus, and improve the water quality.

Based on Indiana Department of Environmental Management (IDEM) guidelines, each million gallon per day (mgd) of wastewater flow requires approximately 10 acres of wetland area for effective removal of nutrients. With a series of low-head dam impoundments, it may be possible to locate constructed wetlands in the narrow riparian areas of Fall Creek. However, it appears unlikely that sufficient space is available, unless further studies demonstrate that a smaller area would remove enough nutrients to adequately control algae and other aquatic plants.

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INSERT FIGURE 13.3

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Based on the Belmont AWT Plant effluent data provided by DPW, a high level of nitrification is achieved, but minimal nitrogen and phosphorus removal. The nitrogen and phosphorus concentrations may be high enough to cause algae and other aquatic plant growth in the creek, and should be evaluated further in future design phases. In addition to nutrient removal issues, the riparian area wetlands may require substantial creek channel improvements for flood control, which would increase the project cost. Portions of the Fall Creek, Pogues Run and/or Pleasant Run Greenways (bike paths, nature trails, etc.) may require re-routing if they become encompassed by the constructed wetlands.

Due to the land area requirements and associated costs, it is recommended that further consideration be given to mechanical methods at the Belmont AWT Plant rather than through wetlands for accomplishing nitrogen and/or phosphorus removal. Possible treatment additions to the Belmont AWT Plant include chemical phosphorus removal with alum injection in the final clarifier or denitrification with methanol injection in the force main. These preliminary treatment alternatives require further evaluation to determine their feasibility.

Currently, the Belmont AWT Plant has the capability to produce and feed ozone. The ozone generation facility is currently off-line, but DPW plans to re-commission the facility within the next couple of years. The addition of ozone during treatment should provide higher DO levels in the plant effluent. Higher DO levels should not affect the outfall structure recommendation.

Discounting effective nutrient removal, wetlands also can be used from an aesthetic standpoint, and have been considered in combination with aeration outfall structures as a possible outfall alternative.

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13.2 Fall Creek Outfall Structure

As indicated by the DPW, 20 mgd of flow is recommended for augmentation for Fall Creek during dry weather periods. Preliminary investigations and planning have identified an outfall location downstream of Keystone Dam. The Department of Water (DOW) has an intake structure for the Fall Creek Water Treatment Plant just upstream of the dam and utilizes the dam to pool the water in Fall Creek, thus contributing to the low flow conditions downstream during dry weather periods. It is also noted that this location is upstream of several CSO locations along Fall Creek.

13.2.1 Cascade Aerator Preliminary Sizing

The 20 mgd for flow augmentation along with the estimated supplemental DO requirement, as described earlier in section 13.1, have been considered for the preliminary design of the cascade aerator alternatives.

The structure is anticipated to be positioned about 250 feet downstream of the base of Keystone Dam near the south bank of the creek channel. Detailed survey and elevation information of the site was not available during this conceptual design stage. However, based on site visits and study of topographic maps, it is anticipated that the top of the structure will be lower than the walking trail. During subsequent detailed design phases, the elevations and site grading will need to be reviewed and finalized based on site survey information.

13.2.1.1 Stair-Step Cascade Aerator Structure

Effluent from the Belmont Force Main would emerge vertically from the pipeline to the center of the top step which is eight feet in diameter. The reclaimed water cascades from the center of the structure from step to step, and is distributed equally around 360 degrees. Each circular step drops one foot and each step is

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four feet larger in diameter than the previous step. The base of the structure at grade is 48 feet in diameter.

13.2.1.2 Side-Stream Cascade Aerator Structure and Alternative Structure

Effluent from the Belmont Force Main would cascade down from the top of the side-stream cascade aerator structure, which is composed of 10 steps that are two feet in length. Each step has a 1-foot elevation drop and the width of the overall structure is 60 feet. The side-stream cascade structure alternative (i.e., large rocks) constructed with large rocks in lieu of concrete steps has the same design parameters and profile. Figure 13.4 shows a possible location, and plan and profile views of the side stream aerator.

13.2.2 Cascade Aerator with Small Constructed Wetland

In addition to the benefits of flow augmentation provided by the outfall structure on Fall Creek, a constructed wetland was evaluated. It was stated by Indy Parks Greenways (refer to Appendix L) that a constructed wetlands area utilizing City property had the potential to:

1) Enhance public opinion about the Long Term Control Plan
2) Serve as a biofilter to improve water quality in Fall Creek and the White River watershed
3) Create needed quality habitat, thereby contributing to the restoration of Fall Creek
4) Provide environmental education opportunities for Indianapolis residents and visitors

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INSERT FIGURE 13.4

13. OUTFALL STRUCTURES

A small constructed wetland was considered for the location shown in Figure 13.4, and could be formed by building a 150-foot long, one foot high weir across the creek channel. The weir would be located approximately 500 feet downstream of Keystone Dam. This two to three acre wetland would be provided for aesthetic reasons and not for effective nutrient removal. As explained in Section 13.1.2, a significantly large area would be required to achieve enough nutrient removal to control algae and other aquatic plants downstream of the wetland. It is estimated that aeration by water flowing over the wetland weir in combination with the wedding cake or side-stream aeration structure would provide the required increased DO concentrations. Figure 13.5 shows the proposed location and plan view for this option utilizing a side-stream aerator structure. During periods of high flow, the wetlands may be subjected to floating debris and the potential loss of wetland flora and fauna without the inclusion of flooding protection measures.

After further review and per the recommendations of DPR Greenways, an alternate site located to the east of Keystone Avenue was also evaluated. This location would utilize floodplain area managed by the City of Indianapolis to increase the size of the constructed wetland from two acres to approximately 10 acres. Increasing the constructed wetland size improves potential nutrient removal, increases available wildlife habitat, and overall function of the wetland.

An overall plan view of this alternative location is shown in Figure 13.6. A side-stream aerator structure utilizing large rocks was selected in an effort provide a more “natural” looking structure in alignment with DPR Greenways desired theme. In addition to the cascade aerator and constructed wetland, the following components were added to further enhance the project, as per the recommendations indicated in Appendix L:

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Figure 13.5

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Figure 13.6

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1) Observation Deck – One deck approximately 30 feet in diameter.
2) Boardwalk – Six feet wide walkway connected to the observation deck.

Further project enhancements/discussions including invasive exotic vegetation removal, debris removal, wetland plantings, natural erosion control, and potential partners can also be found in Appendix L. Additional evaluation of the proposed wetland should be completed during future design phases to determine the feasibility of this option.

13.2.3 Side-Stream Cascade Aerator Structure Downstream of Keystone Dam

The initial cascade aerator structures described in Section 13.1.1 are expected to increase the DO in the Belmont Force Main effluent near saturation. However, the remaining BOD demand in the effluent may deplete the DO in the creek to lower concentrations downstream. A side-stream aerator structure was considered downstream of the initial aerator structure to increase the DO levels back to near saturation. It is assumed that a feasibility study will be conducted to determine the need for an additional side-stream aerator.

If it is determined that the lowest DO concentration, or "sag", in Fall Creek is less than 5.0 mg/L, the side-stream cascade aerator described in Section 13.1.1.2 would be recommended. IDEM Water Quality Standards stipulate that to protect aquatic life in surface waters, the DO concentration should average at least 5.0 mg/L per calendar day and not drop below 4.0 mg/L at any time. The feasibility study should include a component to determine the most appropriate location for the aerator facility.

For purposes of this report, the estimated location for the side-stream aerator would be approximately three miles downstream of Keystone Dam near 32nd

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Street and Fall Creek Parkway. The major facility components include a low head diversion weir, intake pipeline, submersible pumps, and a rectangular-shaped stair-step aeration structure. The diversion weir, or low head dam, would be about two to three feet high and would back up the water in the creek, allowing the water to flow through the intake pipeline to the submersible pumps. Two 50 horsepower (hp) submersible pumps would lift up to 20 mgd of flow 10 feet from the creek to the top of the aerator structure. The aerator structure would consist of 10 steps that are two feet in length. Each step would have a 1-foot elevation drop, and the width of the structure would be 60 feet. The plan and profile views of the facility are presented in Figures 13.7 and 13.8.

DPW indicated that sodium hypochlorite currently is being used for disinfection at the Belmont AWT Plant, but that ozone may be used in the future. Within the next couple of years, the existing ozone generation facility at the Belmont AWT Plant will be upgraded to improve its efficiency and operational. Based on DPW's experience, when the ozone facility was in operation, the Belmont AWT Plant effluent was supersaturated with end of pipe DO concentrations of 10 mg/L or more. It is assumed that in this case, the initial aerator alternatives discussed in Section 13.1.1.1 may not be required. However, a side-stream cascade aerator structure may still be required downstream of Keystone Dam if BOD decay in Fall Creek depletes the dissolved oxygen.

13.3 Pogues Run and Pleasant Run Outfall Structures

As directed by the DPW, 5 mgd of flow augmentation was evaluated for Pogues Run and Pleasant Run. Numerous locations, as shown in Figure 13.9, were reviewed during site visits with members of DPW, Indy Parks, and Indy Greenways for the Pogues Run and Pleasant Run outfall structures.

13. OUTFALL STRUCTURES

INSERT FIGURE 13.7

13. OUTFALL STRUCTURES

INSERT FIGURE 13.8

13. OUTFALL STRUCTURES

INSERT FIGURE 13.9

13. OUTFALL STRUCTURES

Alternative sites considered for Pogues Run include:

1) Brookside Park
2) Forest Manor Park
3) Outfall of existing storm water detention pond near Emerson Avenue and Interstate 70
4) Inlet to existing storm water detention pond near Emerson Avenue and Interstate 70

Alternative sites considered for Pleasant Run include:

1) Christian Park
2) Ellenberger Park
3) Pleasant Run Golf Course
4) Pleasant Run Parkway between 10th Street and 16th Street
5) Shadeland Avenue and 21st Street
6) Pleasant Run intersection with Conrail south of 30th Street

Several of these locations were determined to not be feasible. Discussions with Indy Parks, Indy Greenways, and the DPW identified the above mentioned Parks (including Pleasant Run Golf Course) as being listed as Historical Sites, and therefore not desirable locations for outfall structures.

The two most favorable outfall locations for Pogues Run were at the inlet and outlet structures to the existing storm water detention pond located near Emerson Avenue and I-70. The inlet location is preferred as it provides flow augmentation to the existing 47 acre constructed wetland. A wetland of this size, though not exactly proportional in size to the flow as described in section 13.1.2, would provide a significant improvement in nutrient removal.

13. OUTFALL STRUCTURES

The two most favorable outfall locations for Pleasant Run were at Shadeland Avenue and 21st Street, and at the Pleasant Run intersection with Conrail (south of 30th Street). The Shadeland Avenue and 21st Street location is preferred as it provides the most favorable alternative single force main branch alignment, as shown in Chapter 12.

13.3.1 Cascade Structures

The following outfall alternatives were considered for the Belmont Force Main Lateral(s) terminus at both Pogues Run and Pleasant Run. The configurations are as follows:

- Stair-step cascade aerator structure (see Section 13.1.1.1)
- Side-stream cascade aerator structure (see Section 13.1.1.2)
- Side-stream cascade aerator alternative structure (see Section 13.1.1.3)
- Cascade aerator structure with constructed wetland

13.3.1.1 Stair-Step Cascade Aerator Structure

A preliminary design of the stair-step cascade aerator structure was developed. The desired flow augmentation for both Pogues Run and Pleasant Run is of the same magnitude (5 mgd) and therefore the proposed outfall structures are identical in size. One proposed structure is a “wedding cake” configuration and consists of 10 stair-steps of concentric circles 1 foot high. Effluent from the Belmont Force Main lateral(s) would emerge vertically from the pipeline to the center of the top step, which is 3’-8” in diameter. The reclaimed water cascades from the center of the structure from step to step, and is distributed equally around 360 degrees. Each circular step drops one foot and each step is four feet larger in diameter than the previous step. The base of the structure at grade is 43'-8" in diameter. The structure would be constructed of reinforced, cast-in-place concrete.

Due to the large size of the structure base and the relatively small area occupied by the two creeks, this type of structure is not recommended.

13.3.1.2 Side-Stream Cascade Aerator Structure

A side-stream aerator also was considered as an alternative to the "wedding cake" configuration and again, the structure size is identical for both Pogues Run and Pleasant Run. The side-stream alternative is a rectangular-shaped stair-step aeration structure. The effluent from the Belmont Force Main Lateral(s) would cascade down from the top of the aerator structure, which is composed of 10 steps that are two feet in length. Each step has a 1-foot elevation drop and the width of the structure is 15 feet. The structure would be constructed of reinforced, cast-in-place concrete.

This type of cascade aerator is shown for illustrative purposes in Figures 13.10 and 13.11 at the preferred locations of Pogues Run and Pleasant Run.

13.3.1.3 Alternative Side-stream Aerator Structure

A "natural" looking aeration alternative was also considered. Similar to the concrete aeration structures described above, it is expected that at least 10 feet of drop would be required. The rocks would be arranged in a manner similar to the shape and configuration of the side-stream cascade aerators previously shown on Figures 13.10 and 13.11 except the concrete steps would be replaced by large rocks. This is considered the preferred structure as it enhances the overall aesthetic properties of the project as well as is the most cost effective of the three structures.

13. OUTFALL STRUCTURES

INSERT FIGURE 13.10

13. OUTFALL STRUCTURES

INSERT FIGURE 13.11

13. OUTFALL STRUCTURES

13.3.1.4 Cascade Aerator Structure with Constructed Wetland

A constructed wetland approximately 47 acres in size exists at the anticipated location for the Pogues Run outfall structure. As explained in Section 13.1.2, a wetland of 50 acres is recommended for a stream of 5 mgd in order to achieve enough nutrient removal to control algae and other aquatic plants downstream of the wetland. This existing wetland is large enough to have a significant impact on nutrient removal, and may benefit from the additional flow during dry weather.

At the anticipated location of the Pleasant Run outfall structure, there is no available area downstream of the structure for locating the small constructed wetland.

13.4 FUTURE DESIGN AND CONSTRUCTION CONSIDERATIONS

The current outfall locations were selected based upon flow augmentation goals, site visits, and correspondence with DPW, Indy Parks, and Indy Greenways.

The main goal to be achieved by flow augmentation is the improvement of stream quality including increased DO levels. Considering these goals, it is recommended that the outfall structures be located as far upstream on the creeks as possible to enhance stream quality downstream. Stream augmentation flows of 20 mgd, 5 mgd, and 5 mgd were indicated by the DPW for Fall Creek, Pogues Run and Pleasant Run, respectively. However, based upon further discussions with the DPW, it is recommended that intermediate outfall locations along the creeks be evaluated in the future. The purpose of this future evaluation is to supplement intermediate areas of the streams that have historically shown impaired water quality. Water quality modeling should be completed in later stages of this project to determine the benefits of this approach, and should be completed prior to finalizing the outfall locations. This modeling may lead to multiple outfall locations and the distribution of the flow augmentation needs between them.

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During the site visits, the locations were evaluated to determine the likelihood of the creek in that location to accept the desired flow rates to be introduced for flow augmentation. Items such as stream width, depth, and bank characteristics were evaluated along with information provided by the DPW. As previously indicated, further stream modeling should be completed prior to finalizing the outfall locations to determine the ability of the creeks to accept the indicated augmentation flows, and to indicate the potential affect they may have on stream morphology and water quality.

Further discussions with the DPW resulted in recommendations that the following items be should be investigated during future design phases of this project:

- Erosion and sedimentation effects at the outfall locations and downstream
- Impacts on stream use and water depth
- Potential safety hazards due to increased stream depths and velocities to the public
- Augmented flow rates required for aquatic life and aesthetic improvements
- Potential morphologic impacts
- Potential impacts of Pogues Run outfall structures on the existing constructed wetland and flood control facility

In addition to the recommended stream modeling and impact investigation, future construction considerations should also be evaluated. The aeration structure(s) will be located within the banks of creeks, and the structures will need to be designed and constructed to minimize the potential for damage from floating debris during periods of high flow. The structures should be located near the creek banks where the potential for damage is reduced due to lower velocities. The structures should be provided with chamfered edges to reduce chipping from floating debris. The structures should have deep foundations, which would not only protect the structures from being undermined by erosion, but would also provide additional mass for

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greater stability during high flow events. Potential foaming, algae growth, and odor issues should be considered in the future design of the structures. Aesthetic considerations also are important, as aesthetically-designed structures may enhance the trail and natural appeal of the creek.

13.5 OPERATION AND MAINTENANCE

The aeration structure alternatives are expected to require minimal operation and maintenance. Since the structures would be constructed of cast-in-place concrete, periodic maintenance would be limited to trimming vegetation and removing any accumulated debris around the structure. Flap gates should be provided on the structure discharge opening to prevent debris from entering the Belmont Force Main, and as a safety measure to prevent unauthorized entry by the public or animals. The flap gates will need to be checked periodically to confirm their operation, and for maintenance purposes.